

THURSDAY, MARCH 4, 1880

THE MEDUSÆ

Das System der Medusen; erster Theil einer Monographie der Medusen. Von Dr. Ernst Haeckel, Professor an der Universität Jena. (Jena: Gustav Fischer, 1879.)

THIS is one of the most beautiful books which the science of zoology, which is rich in beautiful books, can boast of. The Medusæ are the most graceful, delicate, exquisitely formed and withal the most rare and inaccessible of living things. No inlander has any notion of what these tender, translucent beings can show in the way of colour, symmetry, and rhythmic movement. They cannot be carried to distant aquaria—but live only in the clearest, brightest parts of the sea at some distance from the coast. No system of pickling fluids is known which can keep them for us undistorted. To study them, even to see them at all as they are, the naturalist must betake himself to the coast and in calm weather sweep the surface of the sea with his towing-net, much as the insect-man sweeps the hedge-rows. Many and some very lovely forms occur on our own coast—but our capricious climate renders it always uncertain when or where any of the Medusæ may be found, sensitive as they are to every change in the movement of the waters, and sinking far out of reach in certain states of weather. The Mediterranean, with its more genial atmosphere and sheltered bays, has always furnished naturalists with the richest supply of pelagic animals, whilst even the mid-ocean is more favourable as a hunting-ground for them than our ever-restless Channel and North Sea.

The term Medusa dates from the time of Linnæus. Peron and Lesueur and after them Eschscholtz were the first naturalists who devoted monographs to the Medusæ, and valuable as was their work it contained descriptions of only some dozen genera and species (1829). After a long interval (1848) Edward Forbes, who was attracted by the symmetrical forms and delicate contours of these animals as he was by the more rigid and less beautiful starfishes, published his monograph of the naked-eyed Medusæ (Ray Society). After him we have, amongst others, the valuable anatomical investigations of Gegenbaur (*Zeitschr. für wiss. Zoologie*, 1857), and the important treatises of the two Agassizs, father and son (Louis Agassiz, "Contributions to the Nat. Hist. of the United States," 1857-62; Alex. Agassiz, "Catalogue of Acalephæ," 1865). Still later we have the magnificent volumes of another artist-naturalist—Prof. Allman—who shows in every line of his pencil how keenly he appreciates the grace and elegance of the hydroid polyps and their medusa-offspring, to which his two large volumes are devoted (Ray Society, 1871). Allman's treatise more especially aims at giving an account of the naked hydriform polyps and the medusæ which are produced like fruit upon their branches, separating and swimming away in many instances as free independent creatures, though sometimes aborted and fixed as sporosacs. Ernst Haeckel, on the other hand, has not proposed to himself to trace the individual life-history of the Medusæ. He takes them as he finds them, and whilst giving us in this first part alone twenty quarto plates of drawings mostly from the

life, exposes their agreements and variations of structure in the most masterly, exhaustive, and logically conceived treatise which it has been our lot to encounter in zoological literature. The symmetry and precision which Haeckel is able to exhibit in his systematic discussion of the Medusæ is no doubt in large degree attributable to the isolated and strongly marked character of the natural group which they form; it is however also in no small measure due to the exhaustive knowledge of their structure which his own researches spread over some twenty years, and more recently those of his pupils, the brothers Hertwig have brought together.

There are very few if any groups of animals so extensive in distinguishable variety of form, the detailed anatomy of which is so well known as is now that of the Medusæ. Hence the thoroughly satisfactory character of the systematic classification of them which is possible.

Unfortunately the life-history of a large number of Medusæ is not so well known, and probably for a long time will not be known. It is a fact familiar to even the least profound student of zoology, that whilst some medusæ are produced by budding from colonies of hydriform polyps and give rise by their eggs to such hydriform colonies which again produce these sexual medusa-forms by budding, yet other medusæ develop directly from the egg of a parent medusa into young medusæ without ever having anything to do with hydriform colonies or "persons." This interposition of a hydriform stage and an act of fissiparous generation appears to have little if any relation to the varieties of structure presented by medusæ. Medusæ closely allied may some have hydriform young and others not. On the other hand the hydriform polyps exhibit the same kind of irregularity in their proceedings, some species producing the neatest of medusæ which swim away to carry their seed far and wide, whilst closely similar species produce not free-swimming elegant medusæ but aborted wart-like knobs (sporosacs), evidently the degenerate representatives of medusæ; and these, without being detached, develop the eggs and the sperm from which a new generation of hydra-forms will spring.

Clearly, then, there was room for a treatise on the Medusæ which should, without waiting for the long process of growth of knowledge, ignore the hydriform phase, just as the admirable monograph of Allman treats of the hydra-forms (of a limited group) without touching those medusæ not yet traced to hydriform parentage.

It appears that in certain large outlines a classification is possible which shall hit off simultaneously the relationships of both medusa-forms and their respective hydra-forms. But that this should extend into the details of small groups, such as families and genera, is not to be expected. Beyond a certain limit the Medusæ and their parentally related hydra-forms *do not vary concomitantly*.

A systematic and exhaustive treatise on Medusæ, as such, was then, we would insist, a great want. No one but the most energetic and industrious of men endowed with the greatest skill as a draughtsman and devoting himself for years to work on such coasts as those of the North Sea, Bay of Biscay, Adriatic, Mediterranean, and Red Sea, such a man as we have in Prof. Ernst Haeckel, could have produced the desired treatise. Besides living specimens, Haeckel has studied those received in alcohol

from all parts of the world, including some collected by the *Challenger*.

We could wish some of our readers who may know Ernst Haeckel only as the populariser of Darwinism and the opponent of Virchow's proposal to establish a scientific popery, to go through the work which he has just produced. Much as we value Haeckel's speculations and his championship of free science, we are ready to admit that in such work as the present he is seen at his best. Speculation and polemics are here far out of sight indeed—the work is of the most solid and genuine character. Page after page is devoted to the systematising and exposition of an immense mass of facts—facts as hard and stubborn as any anti-theorist could wish—yet to a large extent new or little considered hitherto, and at the same time as beautiful and fascinating as any region of nature to which the naturalist can turn his attention.

A medusa may be compared in form to an umbrella, a mushroom, or a clapper-bell. This does not suggest the most beautiful set of objects; it is, however, our own fault if we do not finish off our umbrellas and bells with the same elegance which characterises the medusa. The handle of the umbrella, stalk of the mushroom, or clapper of the bell is sometimes quite short and broad, sometimes very long, reaching far away beyond the disk, dome, or bell from which it hangs. It is known as the manubrium, whilst the expanded disk is called the umbrella. The manubrium is hollow and leads up into a wide cavity in the disk, which originally extended right up to its margin, but by the concrescence of its walls is reduced to four or more radiating pouches or canals and a marginal circular canal. The edge of the disk has longer or shorter hollow tentacles (rarely solid) depending from it, and these vary to any extent in the different kinds of medusæ as to their number (from one to some hundreds) and length. The shape of the umbrella is either flat or more or less elevated until it may be quite like an oriental bell or even globular. Besides tentacles we may find on the margin of the disk three kinds of sense-organs, simple eye-spots, simple auditory sacs, or lastly, what I have elsewhere termed "tentaculocysts," modified tentacles which act as auditory organs and have often eye-spots on them as well.

The generative organs (spermaries and ovaries) are usually in separate individuals, and are placed either in the walls of the manubrium or in the walls of the radiating canals or pouches of the disk. All the parts of the disk and manubrium are arranged as radii around a common axis. The first four radii to appear in the course of the growth from a simpler phase of development are called the per-radii, the next four (between these) the inter-radii, the next eight between these the adradii. An organ (lobe, tentacle, canal, or sense-organ) may be therefore per-radial, inter-radial, or adradial in position. The whole of this symmetrically arranged structure is usually of glass-like appearance, yet with some exceptions quite soft and gelatinous. Often the canals, eyes, and generative bodies are picked out with brilliant colour, red or orange, or of a more delicate pink or blue.

The large variety of medusæ now known, amounting to many hundred species, are divided primarily into two great groups, the Hydromedusæ and the Scyphomedusæ. Prof. Haeckel uses Gegenbaur's terms for these, viz., Craspedotæ and Acraspedæ. Eschscholtz and Forbes

had long ago sought for characters by which to define these two large groups. The Hydromedusæ never as medusæ nor in their hydriform phase possess gastral filaments or phacellæ, they always (?) develop their generative organs from the superficial cell-layer known as ectoderm, as shown by Haeckel's pupils, the Hertwigs, and at the margin of the umbrella they always present a delicate in-turned rim, the velum, which is muscular and not penetrated by canals. Further, whenever they do not develop directly from the egg of a parent medusa but pass through a hydriform phase—the polyps are of the shape and character known as hydroids or hydræ. On the other hand the Scyphomedusæ always possess gastral filaments or phacellæ, which are tufts of tentacle-like processes placed in four groups inter-radially on the oral floor of the stomach, where it widens out in the umbrella; they always develop their generative organs from the deep cell-layer known as endoderm, and they never have at the margin of the umbrella a true velum, though one (*Charybdæa*) has a membranous inturned rim which is very like the velum of Hydromedusæ but penetrated by vessels (as shown by Claus). Further the sense-organs of Scyphomedusæ are always tentaculocysts (though these occur also in one group of the Hydromedusæ), and whenever the hydriform phase is exhibited in development from the egg, the polyp is not a "hydra" but a "scyphistoma," with broad disk-like body, and gives rise to medusæ *not* by budding (as in Hydromedusæ) but by transverse fission.

The Scyphomedusæ (*Acraspedæ* of Gegenbaur) are deferred by Prof. Haeckel for another volume; they comprise the large jelly-fish *Aurelia*, *Rhizostoma*, *Cyanæa*, and such forms, as also the very beautiful and interesting *Charybdæa*, and the *Lucernariæ*, these last being forms which combine the characters of polyp and jelly-fish, for they can both fix themselves by a foot-like process of the aboral pole of the umbrella, or loosen their hold and swim the other way up as a medusa. Though medusæ usually swim mouth downwards, yet it is quite common for them to swim sideways or to float mouth uppermost or even to rest on the sea-bottom in that position.

It is to the "Legion" Hydromedusæ that Prof. Haeckel's first volume and twenty plates are devoted. He divides them into two sub-legions—the *Leptolinæ* and the *Trachylinæ*—in each of which are two orders parallel to one another. The *Leptolinæ* are Hydromedusæ, with soft and mobile, originally hollow tentacles; with ECTODERMAL otolith cells, usually budded from a hydriform colony. The *Trachylinæ* have hard and stiff, originally solid tentacles with ENDODERMAL otolith cells (belonging to tentaculocysts), and, as far as is known, develop direct from the egg. The *Leptolinæ* contain the orders *Anthomedusæ* and *Leptomedusæ*; the *Trachylinæ* contain the orders *Trachomedusæ* and *Narcomedusæ*. One order from each sub-legion, the *Anthomedusæ* and the *Narcomedusæ*, is characterised by having its generative organs placed in the wall of the manubrium; whilst the other order in each sub-legion is characterised by having these organs placed in the course of the radiating canals.

The ANTHOMEDUSÆ are further characterised by never having otocysts or auditory organs at all, but always marginal eye-spots. Their tentacles may be simple,

neither forked nor branched when they fall into one of the three families—Codonidæ, Tiariidæ, or Margelidæ. If the tentacles are branched or forked they belong to the family Cladonemidæ. These medusæ all are borne as buds upon hydroid polyps of Allman's sub-class Gymnoblastea, sometimes called the Tubularinæ. Fifty genera of Anthomedusæ with one hundred and twenty species are described, and many are beautifully figured in the plates of Hæckel's work.

The LEPTOMEDUSÆ are characterised in addition to the points above noted by very often possessing marginal otocysts or auditory vesicles. Those which have none have eye-spots instead and belong to the families Thaumantiadæ and Cannotidæ; whilst those with otocysts usually have no eye-spots, often have more than one hundred tentacles, and belong to the families Eucopidæ and Æquoridæ. Whenever the life-history of the Leptomedusæ has been traced they have been found to be budded off from those hydriform colonies known as the Calyptoblasteæ or Campanularinæ; but many have never been traced (Æquoridæ) and perhaps develop direct from the egg. Sixty-one genera and one hundred and forty species of Leptomedusæ are described by Hæckel.

Of the two Trachylina orders the TRACHOMEDUSÆ, with canal-genitals, vary according as the stomach is elongated, tubular, and devoid of a solid stalk (Petasidæ and Trachynemidæ), or short, bell-shaped, and placed on the end of a freely hanging solid stalk (Aglauridæ and Geryonidæ). Thirty-six genera and sixty species of Trachomedusæ are described and many new ones figured. It is to the genus Carmarina of this group and Cunina of the next that Hæckel seventeen years ago devoted most careful study, making known then in a most admirable monograph (*Jenaische Zeitschrift*, vols. i. and ii.) the excessively elaborate structure of these forms, far exceeding in histological differentiation and complex adaptation of structure to function anything known in the other Hydromedusæ. Here long since Hæckel had described a highly complex nervous system and sense-organs which recent investigations have confirmed and extended to other groups.

All the details of this work are fully summarised in the most systematic way in the present volume. Under the heading "Order—Trachomedusæ" we have, as in the case of each previous order, a systematic survey of the various organs, their histology, and external form; again, under each family a similar survey, narrower in scope and minuter in detail is given and finally each genus and species in turn has its special features not already included in what has been said of the family, fully exposed.

The second order of Trachylina, the Narcomedusæ, with gastral-genitalia, have, in addition to the characters noted in the paragraph above, their auditory tentaculocysts provided with otoporæ or rivets, which fix them into the jelly-like substance of the umbrella, and which are similar in origin and character to the curious peronæ by which the tentacle-roots plunged as it were into the sides of the umbrella-jelly (not therefore placed at its margin) are connected with the hard marginal ring of the umbrella. The Cunanthidæ and Peganthidæ are the families which possess otoporæ, whilst the Æginidæ and Solmaridæ, though possessing peronæ, have no

otoporæ. Twenty-three genera and seventy-five species of Narcomedusæ are described, and several figured.

We thus have no less than four hundred species of Hydromedusæ described by Prof. Hæckel, but he is careful to point out with reiterated emphasis in reference to each order, that since the Medusæ described are known in the course of their individual growth and development to alter their characters very much—such as number and position of tentacles, of radiating canals, and of sense-organs—and since at the same time it is known (just as in the vertebrate Amblystoma) that these Medusæ may and often do become sexually ripe before they have completed their changes, in fact whilst they are still very far from full growth or elaboration (pædogenesis)—it is not obvious what we are to consider a "bona species" among medusæ. What, again and again, asks Hæckel, is the criterion of a good species among Anthomedusæ, among Leptomedusæ, among Narcomedusæ, among Trachomedusæ? The inference is that there is no criterion, there are no such things as "good species." We must be content with form-species; which, in fact, is all that we, as a rule, can get at or know anything about, even in other animal groups.

It need hardly be said that this splendid book is one which every zoologist must study and enjoy.

E. RAY LANKESTER

LIGHTNING CONDUCTORS

Lightning-Conductors; their History, Nature, and Mode of Application. By Richard Anderson, F.C.S., F.G.S., M.Soc.T.E. (London: E. and F. N. Spon, 1879).

MR. ANDERSON deserves the thanks not only of the scientific world but of the public at large for the very excellent and readable volume which he has produced upon the subject of lightning-conductors. There are few persons who can lay claim to the amount of practical experience which Mr. Anderson brings to bear upon the subject, and still fewer who add to practical experience an extensive and accurate knowledge of all that has been done and written upon the subject on the Continent, in America, and in this country.

The earlier chapters of the author's work are almost purely historical; and, beginning with the days when von Guericke first produced sparks and flashes from his rude globe of sulphur, and when Hauksbee and Gray speculated on the analogies between the crackling sparks and the grander phenomena of thunder and lightning, the reader is made acquainted with the various stages of experimental discovery down to the time of Franklin. From Franklin's letters the author quotes the following memorable and characteristic extract, giving in his own words the reasons which suggested to him the experiment which rendered him famous:—

"Electrical fluid agrees with lightning in these particulars:—

- "1. Giving light.
- "2. The colour of the light.
- "3. In the crooked direction of the flame.
- "4. In the swift motion.
- "5. In being conducted by metals.
- "6. In the crack, or noise, of the explosion.
- "7. The subsisting in water, or ice.
- "8. In the rending of bodies it passes through.
- "9. In destroying animals.